

## Parasites of Parr and Lake Age Chinook Salmon, *Oncorhynchus tshawytscha*, from the Pere Marquette River and Vicinity, Michigan

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**ABSTRACT:** Changes in the parasite fauna of chinook salmon, *Oncorhynchus tshawytscha* (Salmonidae), were determined by examining 360 fish of various ages at different times and localities from the Pere Marquette River and Lake Michigan, Michigan. Four parasite species infected chinook salmon parr from the Pere Marquette River, with *Acanthocephalus dirus* being most common. Ten parasite species infected age 0 salmon from Lake Michigan. In these fish, prevalence and mean intensity of *A. dirus* decreased and another acanthocephalan, *Echinorhynchus salmonis*, was found in increasing numbers in older salmon from Lake Michigan. Eight parasite species infected age 1 fish from Lake Michigan and 7 infected adult fish that had returned to the river to spawn. Cestodes were found only in chinook salmon from Lake Michigan and in mature adults that had returned to the river to spawn. Parasites infecting parr from the river were not found in salmon in the lake except for *A. dirus* in one fish. Changes that take place in the parasite fauna of chinook salmon from the Pere Marquette River and Lake Michigan are related to fish age, diet, and movements. Additional information on movements of salmonids and changes in their parasites is provided by the examination of 156 steelhead, *Oncorhynchus mykiss*, and 67 coho salmon, *Oncorhynchus kisutch*, of various ages at different times and localities from the Pere Marquette River.

**KEY WORDS:** *Oncorhynchus tshawytscha*, *Oncorhynchus kisutch*, *Oncorhynchus mykiss*, Salmonidae, fish migration, parasites, survey, Pere Marquette River, Lake Michigan, Michigan.

Several publications, listed and (or) summarized by Margolis (1970) and Margolis and Arthur (1979) as well as Haderlie (1953), Pennell et al. (1973), Olson (1978), and Jennings and Hendrickson (1982) have studied parasites of salmon from Canada and the northwestern United States. These studies as well as those of Dogiel (1966) and Dogiel et al. (1970) have documented changes in the parasite fauna of anadromous salmonids during their lifetime. These changes in the parasite fauna are related to differences in diet and to movements of salmon from freshwater to the marine environment and back to freshwater.

Although the parasites of salmon, *Oncorhynchus* spp., have been studied in the Great Lakes (Collins and Dechtiar, 1974; Lankester and Smith, 1980; Amin, 1985; Muzzall and Peebles, 1986; Dechtiar and Christie, 1988; Dechtiar et al., 1988; Dechtiar and Lawrie, 1988; Muzzall, 1989), investigations on changes in the parasite fauna of parr and lake age salmonids in relation to their movements and diet have not been done. The present study identifies parasites acquired by parr in the Pere Marquette River, Michigan, and examines the changes in the parasite faunas of salmonids migrating from the river to Lake Michigan and then returning to the river as ma-

ture adults. Emphasis is placed on the parasites of chinook salmon, *Oncorhynchus tshawytscha*, with supplemental information provided on parasites of steelhead, *Oncorhynchus mykiss*, and coho salmon, *Oncorhynchus kisutch*.

### Materials and Methods

The Pere Marquette River is located in west-central lower Michigan. It flows east to west for more than 160 km through Lake and Mason counties into Pere Marquette Lake, which empties into Lake Michigan at Ludington. A total of 360 chinook salmon were collected in May, August, and September 1983, July and August 1989, and May–October 1990. Fish were collected by angling, electrofishing, and drift nets from 3 localities in the Pere Marquette River, Weldon Creek (a tributary of the Pere Marquette River), and Lake Michigan in close proximity to the mouth of the river (Fig. 1). One hundred fifty-six steelhead and 67 coho salmon from various localities were also examined for parasites. Age categories of salmonids were based on known length–age relationships (R. Elliott, unpubl.). Salmon were not aged by scale analysis. Salmonids were described as: parr (ages 0 and 1) inhabiting the Pere Marquette River that had not moved to Lake Michigan, lake age fish (ages 0 and 1) that had entered Lake Michigan, or adults (ages not determined) that had returned to the river to spawn. Salmon parr collected in the Pere Marquette River system are a result of natural reproduction (Carl, 1982).

Approximately 300 salmonids were examined within 24 hr of collection. Others were killed and frozen or

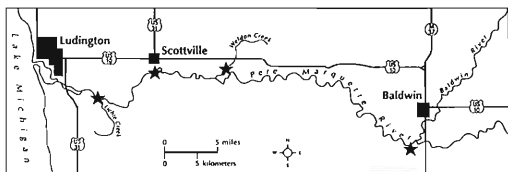


Figure 1. Map of the Pere Marquette River and sampling localities (\*, sampling localities).

preserved in 15% formalin for later examination. In the necropsy of parr, the entire fish was examined. Total length (mm) and sex of most fish were recorded. The digestive tract, associated viscera, gills, and in some cases, eyes of adults were examined. Helminths and copepods were counted and processed using conventional techniques. Prevalence is the percentage of fish infected, and mean intensity is the mean number of worms per infected fish. Parasites considered to be of river origin and of lake origin are those acquired by salmonids in the Pere Marquette River system and in Lake Michigan, respectively. Voucher specimens of the following parasites have been deposited in the U.S. National Museum (USNM) Helminthological Collection: *Cyathocephalus truncatus* (USNM# 82310), *Diphyllbothrium* sp. (USNM# 82311), *Eubothrium salvelini* (USNM# 82312), *Proteocephalus* sp. (USNM# 82313), *Capillaria salvelini* (USNM# 82314), *Cystidicola farionis* (USNM# 82315), *Haplonema hamulatum* (USNM# 82316), *Spinitectus gracilis* (USNM# 82317), *Acanthocephalus dirus* (USNM# 82318), *Echinorhynchus salmonis* (USNM# 82319), *Ergasilus lucioperca* (USNM# 82320). *Crepidostomum cooperi* was not retained by the author and therefore not deposited.

### Results

A total of 219 (61%) chinook salmon were infected with 14 parasite species, regardless of age and collecting locality. The 3 protozoan species and *Ergasilus lucioperca* Henderson, 1926 infected the gills. *Cyathocephalus truncatus* (Pallas, 1781), *Eubothrium salvelini* (Schränk, 1790), *Proteocephalus* sp., *Capillaria salvelini* (Polyansky, 1952), and *Spinitectus gracilis* Ward and Magath, 1917 were found in the pyloric ceca or anterior intestine. *Acanthocephalus dirus* (Van Cleave, 1931) and *Echinorhynchus salmonis* (Müller, 1784) occurred throughout the intestine. *Cystidicola farionis* Fischer, 1798 infected the swim bladder. *Diphyllbothrium* sp. was found encysted and unencysted on the surface of the pyloric ceca and in the stomach wall, liver, and spleen. *Haplonema hamulatum* Moulton, 1931 infected the anterior intestine. There was no significant difference in prevalence (chi-square analysis) and intensity (Student's *t*-test) with respect to host gender ( $P > 0.05$ ).

Twenty-six age 0 parr (mean length = 58 mm) collected in May and August 1983 in the Pere Marquette River, downriver from the Baldwin River junction, were negative for parasites. One *Spinitectus gracilis* infected 1 of 7 age 1 parr (mean length = 133 mm) from this locality in August 1983. Parasites were not found in 27 age 0 parr (mean length = 91 mm) collected in August 1983 from Weldon Creek. Four parasite species infected age 0 parr collected downriver of Lichte Creek (Table 1). *Acanthocephalus dirus* had the highest prevalence, and *S. gracilis* had the highest mean intensity. Age 1 parr from this locality had a higher prevalence and mean intensity of *A. dirus* than did age 0 parr. Percentages of chinook salmon parr infected by age were: age 0 (37%), age 1 (50%).

Ten parasite species infected lake age 0 chinook salmon from Lake Michigan. *Acanthocephalus dirus* had a lower prevalence and mean intensity in these fish in July and August 1989 compared to parr in the river. One age 0 fish from Lake Michigan in September 1990 harbored *A. dirus*. It was not found in lake age 1 fish in September and October 1990 nor in adults that returned to the river to spawn. *Echinorhynchus salmonis* first appeared in age 0 fish from Lake Michigan in July 1989. Prevalence and mean intensity increased in older, larger lake age 0 fish collected in September and October 1990 and in lake age 1 fish from June through August 1990. Eight parasite species infected age 1 fish from Lake Michigan and 7 species infected mature adults. Cestodes were found only in age 0 fish in October and November 1990, in age 1 fish from the lake, and in adults. Percentages of chinook salmon infected in Lake Michigan by age were: age 0 (64%), age 1 (69%). All adults from the river were infected. A total of 13 parasite species infected chinook salmon in Lake Michigan and adults on their spawning run in the river. However, only 4 species infected parr in the river. Parasites infecting salmon in the lake and adults returning to spawn were not found in parr in the river and parasites infecting parr from the river were not found in salmon in the lake except for *A. dirus* in one fish.

Steelhead and coho salmon were examined for parasites at different times and localities from the Pere Marquette River system (Table 2). Ten parasite species (1 Monogenea, 1 Digenea, 3 Cestoda, 1 Nematoda, 2 Acanthocephala, 2 Protozoa) infected steelhead (Table 3). Fourteen (11%)

Table 1. Prevalence (P) and mean intensity (MI) of parasites in *Oncorhynchus tshawytscha* of various ages from different localities in the Pere Marquette River and Lake Michigan.

Locality (date collected):		PMR*, downriver of Lichte Creek (5/90, 6/90)			PMR, downriver of Lichte Creek (5/90)			LM†, near mouth of PMR (7/89, 8/89)			LM, near mouth of PMR (6/90, 7/90, 8/90)			PMR, south of Scottville (9/83)		
Number examined (fish age mean length in mm):		89 (0 parr, 84)			11 (1 parr, 129)			76 (0, 154)			10 (1, 332)			80 (adult, length not measured)		
Parasite		P	MI ± 1 SD (range)		P	MI ± 1 SD (range)		P	MI ± 1 SD (range)		P	MI ± 1 SD (range)		P	MI ± 1 SD (range)	
<b>Protozoa</b>																
<i>Epistylis</i> sp.		1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Trichodina</i> sp.		6	—	—	18	—	1	—	—	—	—	—	—	—	—	—
<i>Trichophyra</i> sp.		—	—	—	—	—	3	—	—	12	—	—	—	—	—	—
<b>Cestoda</b>																
<i>Cyathocephalus truncatus</i>		—	—	—	—	—	—	—	6	1	20	2.0 ± 1.4 (1-3)	5	—	1	—
<i>Diphyllobothrium</i> sp.†		—	—	—	—	—	—	—	9	1	10	1	70	4.7 ± 5.9 (1-31)	—	—
<i>Eubothrium salvelini</i>		—	—	—	—	—	—	—	—	—	10	3	11	3.2 ± 2.4 (1-9)	—	—
<i>Proteocephalus</i> sp.‡		—	—	—	—	—	—	—	3	1	10	1	15	1.9 ± 1.4 (1-5)	—	—
<b>Nematoda</b>																
<i>Capillaria salvelini</i>		—	—	—	—	—	—	—	—	—	—	—	23	6.4 ± 10.2 (1-42)	—	—
<i>Cystidicola farionis</i>		—	—	—	—	—	3	2	—	—	20	2.5 ± 2.1 (1-4)	—	—	—	—
<i>Haplonema hamulatum</i> ‡		—	—	—	—	—	—	—	—	—	—	—	3	1	—	—
<i>Spinictetus gracilis</i>		6	4.0 ± 4.8 (1-12)	18	1.5 ± 0.7 (1-2)	4	1.3 ± 0.6 (1-2)	—	—	—	—	—	—	—	—	—
<b>Acanthocephala</b>																
<i>Acanthocephalus dirus</i>		51	2.7 ± 3.1 (1-14)	55	4.5 ± 2.5 (2-8)	9	2.6 ± 2.5 (1-8)	3	11	—	—	—	—	—	—	—
<i>Echinorhynchus salmonis</i>		—	—	—	—	46	10.1 ± 20.2 (1-112)	100	23.5 ± 40.4 (1-241)	100	216.1 ± 123.2 (25-429)	100	302.5 ± 463.8 (4-2,643)	—	—	—
<b>Copepoda</b>																
<i>Ergasilus luciopercarum</i>		—	—	—	—	1	1	4	1	10	1	—	—	—	—	—

\* PMR, Pere Marquette River.  
† LM, Lake Michigan.  
‡ Larval or immature helminth, no footnote indicates gravid helminths found.

**Table 2.** Numbers and mean lengths of parr and adult *Oncorhynchus mykiss* and *Oncorhynchus kisutch* examined from different localities in the Pere Marquette River system.

Species	Locality*	No. examined	Mean length (mm) ± 1 SD	Dates collected
<i>Oncorhynchus mykiss</i>	BRJ	44 P†	104 ± 45	8/83, 9/83
	WC	79 P	108 ± 46	8/83, 9/83
	WCJ	25 A	—	9/83
	LC	8 P	193 ± 15	6/90, 7/90
<i>Oncorhynchus kisutch</i>	WC	61 P	91 ± 10	8/83, 9/83
	WC	3 A	—	9/83
	S	3 A	—	9/83

\* BRJ, downriver of Baldwin River Junction; WC, Weldon Creek; WCJ, downriver of Weldon Creek Junction; LC, downriver of Lichte Creek; S, Scottville.

† P, parr; A, adults.

of 131 parr and 24 (96%) of 25 adults harbored parasites. Four parasite species infected parr. Of the infected parr, 10 had external parasites only. Six helminth species, 5 of which were of lake origin, infected adults that had returned to spawn. *Echinorhynchus salmonis* had the highest prevalence and mean intensity in adult steelhead and coho salmon. Four parasite species (3 Cestoda, 1 Acanthocephala), all of lake origin, infected adult coho salmon that returned to the river to spawn. All 61 coho salmon parr from Weldon Creek were negative.

### Discussion

Fourteen parasite species were found in chinook salmon, 10 in steelhead, and 4 in coho salmon from the Pere Marquette River system and Lake Michigan. Eleven (69%) of the 16 parasite species found in *Oncorhynchus* spp. are endoparasites, most of which inhabit the digestive tract. With few exceptions, most endoparasites are acquired by salmonids through feeding on infected intermediate hosts. *Echinorhynchus salmonis* and the cestodes (except for *Cyathocephalus truncatus*) infected adult chinook salmon, coho salmon, and steelhead. Adult chinook salmon and steelhead shared *Cystidicola farionis*.

Four parasite species infected chinook salmon parr, and 4 species (3 of which occurred on the gills) infected steelhead parr from the river. None of 61 coho salmon parr was infected. Based on numbers, stomach content analyses indicated that parr of *Oncorhynchus* spp. from Weldon Creek and the downriver localities were feeding primarily on terrestrial organisms (isopods, millipedes, slugs, spiders), and a few amphipods and mayfly larvae. Collins and Dechtiar (1974) and Muzzall and Peebles (1986) reported a similar lack of parasites in parr in tributaries of the Great

Lakes. Parts of the Pere Marquette River have been treated with the lampricide, 3-trifluoromethyl-4-nitrophenol (TFM). Merna (1985) reported that a portion of the Baldwin River treated with TFM had reduced numbers of aquatic benthos when compared to control areas. The use of TFM in the Pere Marquette River system may have reduced the number of possible intermediate hosts or even eliminated some species.

Chinook salmon and coho salmon were successfully introduced into the Great Lakes in 1967 and 1966, respectively. The comparably low number of parasite species in chinook salmon parr and the lack of parasites in coho salmon parr in the present study may be due to the fact that these species have not been in the Pere Marquette River system long enough to establish a variety of host-parasite relationships or, because they spend such a short time in this river.

The present study demonstrates that changes that take place in the parasite fauna of chinook salmon of various ages, from various localities and from discontinuous years in the Pere Marquette River and Lake Michigan are related to fish age, diet, and movements. Parr, collected downriver from the Baldwin River and Weldon Creek, harbored only 1 *S. gracilis*. As fish became older (larger), moved into the larger stretches of the river (Lichte Creek area), and their diet became more diverse, they were infected with 4 species of parasites. In the Lichte Creek area, *A. dirus* was the most common parasite in age 0 parr. Gut content analyses indicated that parr began to feed on isopods, which are known intermediate hosts for *A. dirus* (see Amin et al., 1980; Muzzall, 1984). *Spinitectus gracilis* became more abundant in parr at this locality, and *A. dirus* was most common in age 1 parr.

**Table 3. Parasities of 131 parr and 25 adult *Oncorhynchus mykiss* and 6 adult *Oncorhynchus kisutch* from different localities in the Pere Marquette River system.**

Parasite	Host	Locality*	Prevalence	Mean intensity ± 1 SD (range)
Monogenea				
<i>Gyrodactylus</i> sp.	<i>O. mykiss</i> P†	BRJ	1	—
Digenea				
<i>Crepidostomum cooperi</i>	<i>O. mykiss</i> A	S	4	1
Cestoda				
<i>Diphyllbothrium</i> sp.‡	<i>O. kisutch</i> A	S	50	2.7 ± 1.2 (2–4)
	<i>O. mykiss</i> A	WCJ	4	1
<i>Eubothrium salvelini</i>	<i>O. kisutch</i> A	S	33	2.0 ± 1.4 (1–3)
	<i>O. mykiss</i> A	WCJ	48	13.8 ± 16.0 (2–44)
<i>Proteocephalus</i> sp.	<i>O. kisutch</i> A	S	83	29.2 ± 46.4 (5–112)
	<i>O. mykiss</i> A	WCJ	4	1
Nematoda				
<i>Cystidicola farionis</i>	<i>O. mykiss</i> A	WCJ	1	2
Acanthocephala				
<i>Acanthocephalus dirus</i>	<i>O. mykiss</i> P	LC	2	2.7 ± 1.5 (1–4)
<i>Echinorhynchus salmonis</i>	<i>O. kisutch</i> A	S	100	91.2 ± 89.1 (7–218)
	<i>O. mykiss</i> A	WCJ	96	28.1 ± 9.2 (2–336)
Protozoa				
<i>Epistylis</i> sp.	<i>O. mykiss</i> P	BRJ	3	—
<i>Trichodina</i> sp.	<i>O. mykiss</i> P	BRJ, WC, LC	6	—

\* Locality where parasite infected fish: BRJ, downriver of Baldwin River Junction; S, Scottville; WCJ, downriver of Weldon Creek Junction; LC, downriver of Lichte Creek Junction; WC, Weldon Creek.  
† P, parr; A, adult.  
‡ Larval helminth.

Larger, older chinook salmon in their Lake Michigan phase acquired a richer and more varied parasite fauna than parr in the Pere Marquette River. Reasons for this include piscivory that begins in the oldest age 0 fish as well as a greater volume of food ingested, including intermediate hosts and more fish transport hosts (Hnath, 1969). Similar results have been seen in adult salmon in their marine phase along the west coast (Margolis, 1965; Olson, 1978). In age 0 chinook salmon from Lake Michigan in July and August 1989, *A. dirus* decreased in intensity, *E. salmonis* became most common, and the number of parasite species increased. Gut content analyses indicated that salmon from Lake Michigan were feeding on the amphipod *Pontoporeia affinis*, which is a known intermediate host for *E. salmonis* (see Amin, 1978). Cestodes (*C. truncatus*, *Diphyllbothrium* sp., *E. salvelini*, *Proteocephalus* sp.) and nematodes (*C. salvelini*, *C. farionis*) infected lake age 0 fish in September and October 1990, lake age 1 fish, and adults that had returned to the river to spawn. These cestodes and nematodes, as well as *E. salmonis* and *E. luciopercarum*, are considered to be of Lake

Michigan origin. As adult chinook salmon and coho salmon move into the Pere Marquette River to spawn, their parasites accompany them and die with their hosts. A large number of *E. salmonis* and their eggs are lost when infected salmon die. The mean number of *E. salmonis* in spawning adult chinook salmon is lower than the mean number (330) in adults from Lake Michigan (Muzzall, 1989). Perhaps, the *E. salmonis* populations begin to die off as adult salmon quit feeding before the spawning run. The absence of parasites of lake origin in salmon parr indicates that necessary intermediate hosts are absent in the river.

Data from parr and adult coho salmon and steelhead also demonstrate that the parasite faunas change and become more varied as salmon become larger and move to Lake Michigan. None of 61 coho salmon parr from Weldon Creek was infected. All adult coho, however, harbored at least 1 of 4 helminth species of lake origin (*Diphyllbothrium* sp., *E. salvelini*, *Proteocephalus* sp., *E. salmonis*). Steelhead parr from the upriver localities were infected with external parasites (*Gyrodactylus* sp., *Epistylis* sp., *Trichodina* sp.),

whereas *A. dirus* and *Trichodina* sp. infected parr downriver of Lichte Creek. Adult steelhead were infected only with parasites of lake origin except for *C. cooperi*, which infrequently infect brown trout, *Salmo trutta*, in the river (unpubl.). Adult steelhead may not die after spawning, so their parasites may return with them to Lake Michigan.

It is beyond the scope of this paper to postulate on how useful parasites may be in the future in helping to understand the biology of the salmon in the Great Lakes and on specific effects that they may have upon the survival of their salmon hosts. However, some general comments can be made. First, none of the parasites found in chinook salmon parr in the Pere Marquette River survives throughout the life cycle of the fish. Thus, the parasites found in parr in this study do not appear to have any potential for use as biological tags (see Mackenzie, 1983 for a review of this subject). In addition, *E. salmonis*, which infected most chinook salmon in Lake Michigan and all those returning to spawn, with heavy intensity in some, is known to be detrimental to its host when it is abundant, as reported by Bauer (1953 in Petrochenko, 1956), Petrushevski and Kogteva (1954 in Collins and Dechtiar, 1974), Petrochenko (1956), Bauer (1961), and Petrushevski and Shulman (1961). Thus, *E. salmonis* may be a health concern to salmon in Lake Michigan and returning adults.

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Bethesda, Maryland 20814-4799

26 July–6 August 1993

This course will consist of a series of lectures and hands-on laboratory sessions covering the diagnosis of parasitic infections of humans. In addition to the examination of specimens, participants will be able to practice various methods used in the diagnosis of intestinal, blood, and tissue parasitic diseases. Parasitic diseases encountered throughout the world will be included. Slide presentations and video tapes will be available for study. The course will be held on the University's campus, utilizing up-to-date lecture rooms and laboratory facilities. Microscopes will be available on a loan basis and laboratory supplies will be provided. Certain reference specimens will also be available for personal use.

The registration fee for the two-week course is \$1,000. U.S. Government and Military personnel may take the course at a reduced rate. Those interested should register as soon as possible as the number of students will be limited. CME credits will be available for this course. Previous laboratory experience is recommended. For further information contact Dr. John H. Cross (301) 295-3139, Dr. Edward H. Michelson (301) 295-3138, or Ms. Ellen Goldman (301) 295-3129.